Assistance to Prospectors and the Public in Nova Scotia

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Introduction

The Nova Scotia Department of Natural Resources (DNR) fields many requests each year to identify rocks and rock-like objects collected by citizens of the province who wish to know: what is this?

In the summer of 2017 DNR staff were contacted by Mr. Shawn Sleep, of Dartmouth, who had in his possession a curious object of unknown origin and age, and who wished to know what it might be (Fig. 1). Mr. Sleep found the object, resembling a rock, close to the old downtown area on Portland Street, Dartmouth, between Wentworth and Dundas Streets (UTM NAD 83; E455168 N4946048; Fig. 2) several years earlier and had been speculating as to its origin ever since.

Mr. Sleep suggested several possible origins for the object, including that it might be a meteorite or a shard of the Mont Blanc or Imo from the Halifax Explosion. The explosion, which took place in 1917, is considered to be the largest man-made explosion prior to the first atomic bomb tests. Many shards of steel from these vessels have been found throughout the Halifax–Dartmouth area and two larger pieces are on display in prominent locations very close to where they fell, one in Dartmouth 2.3 km from the explosion site and one in Halifax 3.7 km from the explosion site (Fig. 3).

Methods

Helping Mr. Sleep to identify the object began by considering the likelihood of his own proposals. The object had been broken by Mr. Sleep into several pieces some years earlier, and all the pieces were not present at the first inspection. The pieces of the object present were inspected visually and photographed for documentation. They were measured for magnetic attraction with a Terraplus KT-10 magnetic susceptibility meter. Specific gravity was measured by weighing the object in air and then again in water. Chemical analysis was performed on five samples of the object with a Thermo Fisher Scientific Niton XL-2 X-Ray fluorescence analyzer (XRF).

Results

Visual Inspection

As mentioned, the object was broken into several small pieces by Mr. Sleep. Visual assessment noted only a very lightly oxidized surface with a botryoidal texture on one side (Fig. 4), with metallic, conchoidal fracture patterns along most of the other sides. The area with botryoidal texture was darker than the rest of the groundmass in the

Figure 1. Terry Eyland of the Dartmouth Heritage Museum (left) and Shawn Sleep (right) holding his curious object on the shore of Dartmouth, N.S., not far from the discovery location.

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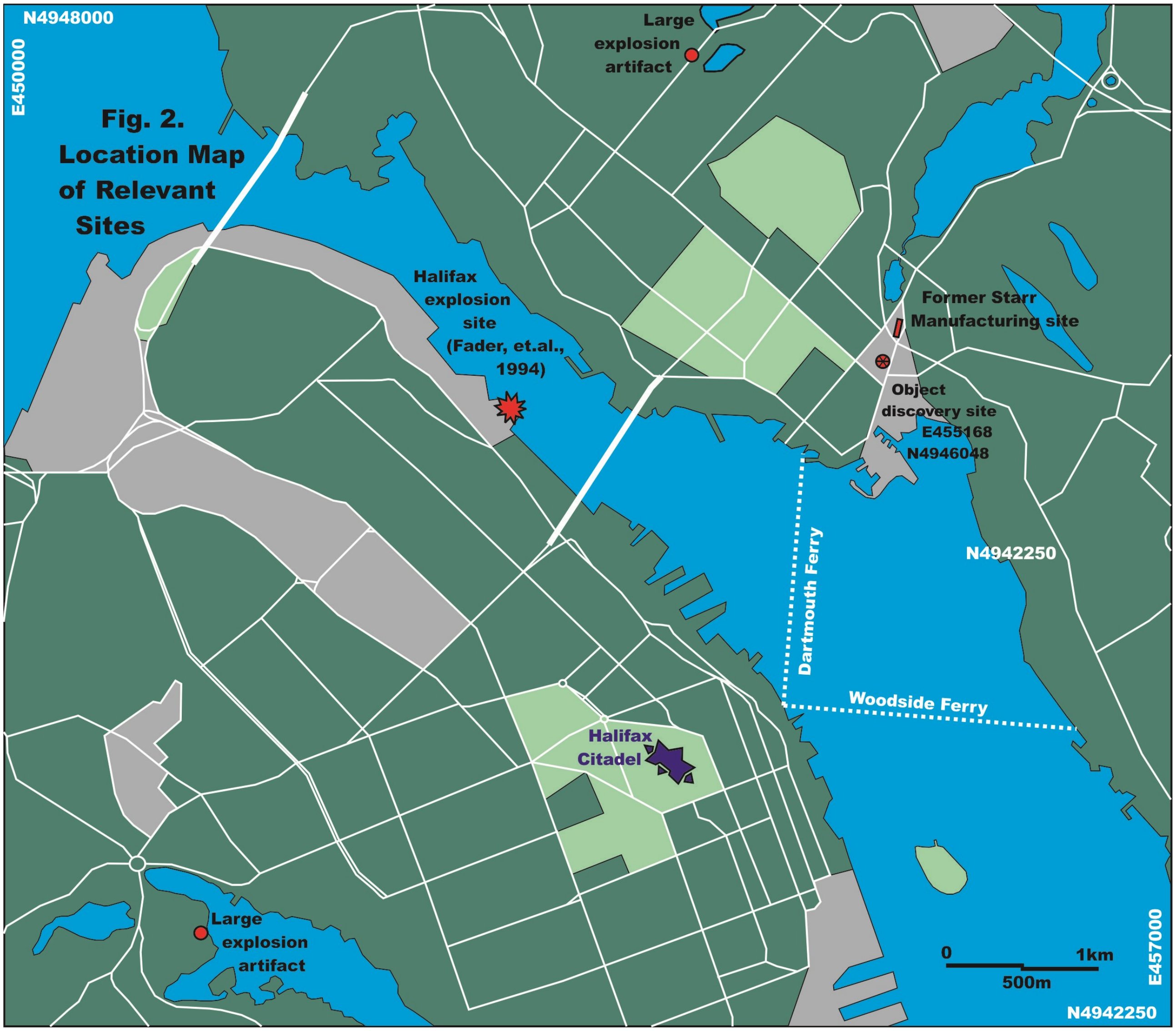

Figure 2. Location map showing relevant sites in the Halifax-Dartmouth area.

Figure 3. Large iron artifacts thrown by the Halifax Explosion. (L) A cannon found in Dartmouth, 2.3 km from the explosion, and (R) an anchor stem found in Halifax, 3.7 km from the explosion site.

sample, and exhibited a crust often seen formed from cooling. The sample appeared to have some regmaglyptic features as well, which might support the meteorite origin. Numerous gas bubbles were noted at the surface of the botryoidal crust (Fig. 5). Planar laminations were visible in the matrix of the object, roughly parallel to the botryoidal crust.

The object was black to dark brown, with red-brown to dark orange staining. It had an oxidized, submetallic lustre, with minor peacock lustre noted on fracture faces in the broken matrix. Although no hardness tests were performed, Mr. Sleep attested to the object's "incredible hardness," and produced a screwdriver he had used to break the object. The screwdriver had been bent at a 45º angle by the force applied to break the specimen (Fig. 6).

Specific Gravity

A piece of the object was weighed in air and water to determine specific gravity. One piece of the object weighed 104.9 g in air, and 77.5 g in water, giving a specific gravity of 3.83.

Magnetic Susceptibility

The object was tested for its magnetic content with a Terraplus KT-10 magnetic susceptibility meter, which measured the magnetic susceptibility in micro Sieverts (10^{-3} SI).

The results for testing magnetic susceptibility are shown below:

Matrix
100.0×10^{-3} SI
101.0×10^{-3} SI
102.1×10^{-3} SI

Crust
51.1×10^{-3} SI
52.0×10^{-3} SI
51.5×10^{-3} SI

Matrix and Crust together
82.6×10^{-3} SI
83.4×10^{-3} SI

X-Ray Fluorescence Analysis

The Department of Natural Resources has a portable X-Ray Flourescence (XRF) analyzer, for the purpose of obtaining chemical analyses quickly and at low cost, for a number of types of geological specimens (rock, soil, mineral separates, etc.). Results of the XRF analyses for a number of elements are presented in Table 1.

Figure 4. Photograph of the object showing botryoidal texture, and regmaglyptic structures in a dark, crusted surface.

Figure 5. Photograph showing gas bubbles in the crusted surface.

Figure 6. This screwdriver was hit by a hammer and used as a chisel to break the specimen into pieces.

Discussion

Visual inspection of the object was done according to the Self Test Check List of Korotev (2018). Despite the presence of the botryoidal crust and regmaglyphtic features, planar laminae noted along one of the fractured surfaces dismissed the object as a meteorite. The lightly oxidized surface was thought on first inspection to be iron^{2+}. This was later confirmed by the magnetic susceptibility tests.

The magnetic susceptibility of the object was considerably high for a natural object, with averages of 101.03 x 10^{-3} SI (microsieverts), for the matrix, 51.53 x 10^{-3} SI for the crust, and 84.66 x 10^{-3} SI for sections where both matrix and crust together were measured. These data correspond to an object consisting of about 50% iron. This was corroborated by the XRF analysis.

Table 1. Chemical analyses (XRF) of five samples from the unidentified object.

Duration	Units	Sb	Sn	Cd	Mo	Nb	Th	Th Error
60sec	ppm	31.93	60.01	25.23	7.75	3.51	7.07	11.8
60sec	ppm	37.74	<LOD	31.99	7.35	2.91	6.66	14.22
60sec	ppm	43.19	48.57	22.01	<LOD	5.1	6.63	10.36
60sec	ppm	28.46	<LOD	33.24	7.08	3.13	6.6	15.69
60sec	ppm	34.41	47.42	22.25	4.93	3.08	3.96	12.01
Duration	**Units**	**Zr**	**Zr Error**	**Y**	**Y Error**	**Sr**	**U**	**Rb**
60sec	ppm	93.39	5.57	9.02	3.15	29.11	3.63	9.14
60sec	ppm	81.16	4.46	5.09	2.49	26.22	2.95	7.24
60sec	ppm	82.35	4.69	9.6	2.77	30.16	3.24	6.67
60sec	ppm	83.32	4.79	4.9	2.69	32.54	3.37	13.69
60sec	ppm	81.01	4.74	6.02	2.73	29.64	3.25	9.87
Duration	**Units**	**As**	**Se**	**Pb**	**Zn**	**Zn Error**	**Cu**	**Cu Error**
60sec	ppm	94.23	13.84	38.68	654.76	42.96	486.83	54.2
60sec	ppm	50.13	9.96	27.49	76.18	18.91	131.37	35.95
60sec	ppm	85.27	11.52	19.19	185.37	24.11	296.5	41.53
60sec	ppm	44.6	12.09	76.85	216.44	25.65	297.19	41.97
60sec	ppm	51.79	11.18	40.12	203.67	25.17	280.62	41.26
Duration	**Units**	**Ni**	**Fe**	**Fe Error**	**Mn**	**Cr**	**V**	
60sec	ppm	1186.42	490011.81	5014.48	2022.11	646.83	3112.28	
60sec	ppm	114.4	455345.53	3924.73	1338.1	553.05	3217.05	
60sec	ppm	210.74	490843.34	4369.67	1918.97	582.07	3241.61	
60sec	ppm	218.01	501023.41	4468.79	2104.57	568.31	2708.75	
60sec	ppm	211.18	499838.91	4347.1	1837.29	562.93	2781.56	

Specific gravity of a sample of the object was found to be 3.83. The object is clearly made largely of iron, yet this specific gravity does not correspond to any obvious iron mineral with a submetallic lustre (e.g. chalcopyrite 4.1 - 4.3, pyrite 4.9 – 5.2, hematite 4.9 – 5.3, magnetite 5.13, pyrrhotite 4.58 – 4.65, bornite 5.0 – 5.1). The object has a specific gravity more closely resembling that of romanechite (3.7 – 4.7; Klein and Hurlbut, 1993). Klein and Hurlbut (1993) list romanechite as having a hardness of 6 – 6.5 on the Mohs scale. This would correspond to that of a very hard object, as described by Mr. Sleep's breaking procedure and the bending of the steel screwdriver-chisel (Fig. 6). Romanechite is a (hydroxy) manganese oxide, commonly added in the steelmaking process to harden alloys.

Five XRF analyses were done on separate locations on different pieces of the object for count duration times of 60 seconds. Overall, the object consisted of approximately 50% iron (Fe), with notable amounts of zinc (Zn), chromium (Cr), nickel (Ni), copper (Cu), vanadium (V) and manganese (Mn).

Copper, nickel, and chromium could be naturally present in such an object. The percentages of iron and manganese, however, closely resemble those of iron produced in Nova Scotia at the Londonderry foundries in the mid 1800s (Hughes, 1995). Chemistry of the first XRF analysis, which was taken from crust, was somewhat different from the rest, indicating a separation of elements during melting. Londonderry was one of North America's premier iron producers at that time, producing iron from oxidized ores such as ankerite, siderite and botryoidal iron, which had a high level of manganese. This contributed to alloy hardness in the steelmaking process from alloys produced in the Londonderry furnaces. Iron from Londonderry was used to pour into pipe molds that would form underground pipes still used for bringing water into cities along the eastern seaboard of North America, such as Boston and New York (Matheson, 1983).

Conclusions

The object exhibits "thumbprint-like" textures on part of it and appears to have a crust on one side. These regmaglyptic shapes are part of the botryoidal texture and are not true regmaglyphs, which are eroded by plasma and found on meteorites. The crust seen on one side is not a fusion crust but is related to the botryoidal texture development as well. The object displays some layering, and is not a meteorite.

The stratification also dismisses the object as a piece of the Mont Blanc or Imo from the Halifax Explosion. Metal alloys of the type found on such vessels would not be layered. This leaves only the possibility that this piece of iron is a leftover remnant of a metal refining process. It is not slag, however, although it displays a small blob of slag on what would have been the top of the object. It is believed to be refined ore, leftover after a poured iron mold was filled, probably from a reservoir which would have continued to fill the mold as the iron cooled and shrank while still viscous. How it came to be buried in the location where it was found remains open to speculation but, the location of the discovery site is not far from a former foundry operated by Starr Manufacturing of Dartmouth. Starr manufactured high strength tensile steel for nails, nuts and bolts, but became especially well known for the production of ice skates, producing over 11 million of them (T. Eyland, Dartmouth Heritage Museum, personal communication). It is possible that small bits of discarded steel from Starr was used as local fill for a construction project in downtown Dartmouth 300 m from the Star Manufacturing site where the object was found (Fig. 2).

References

Fader, G.B., Miller, R.O., and Pecore, S.S., 1994. Sample control, anchor marks, anthropogenic features and lacustrine sediments of Halifax Harbour; Geological Survey of Canada, Open File Report 2958, 32 p.

Hughes, S. 1995. Londonderry Fe Mine (Old Mountain Mines); Nova Scotia Department of Natural Resources, Mineral Occurrence Database, Mineral Occurrence Number E05-055, 5 p.

Klein, C., and Hurlbut, C.S. (after Dana, J.D.), 1993. Manual of Mineralogy; John Wiley and Sons, Toronto, 681 p.

Korotev, R.L. 2018. Meteorite and lunar meteorite information; Department of Earth and Planetary Sciences, Washington University in St. Louis, MO, USA.

Matheson, T. A 1983. History of Londonderry, N.S.; Lancelot Press, Hantsport, N.S., 207 p.